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Geology of Lake McConaughy Area, Keith County, Nebraska

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GEOLOGY OF LAKE McCONAUGHY AREA KEITH COUNTY NEBRASKA

Roger K. Pabian and R. F. Diffendal, Jr.



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**Roger K. Pabian
and
R. F. Diffendal, Jr.**

Illustrated by Frankie Gould

**CONSERVATION AND SURVEY DIVISION
INSTITUTE OF AGRICULTURE AND NATURAL RESOURCES
THE UNIVERSITY OF NEBRASKA-LINCOLN**

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FACTORS FOR CONVERTING ENGLISH UNITS TO THE INTERNATIONAL SYSTEM OF UNITS (SI)

Multiply English Units	By	To obtain SI units
	Length	
inches (in)	25.4	millimeters (mm)
feet or foot (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
	Area	
acres	4047	square meters (m ²)
square miles (mi ²)	2.590	square kilometers (km ²)
	Volume	
acre-feet (acre-ft)	1233	cubic meters (m ³)
	Flow	
gallons per minute (gpm)	.00006309	cubic meters per second (m ³ /s)

Introduction

Rocks cropping out along the North Platte River valley at Lake McConaughy provide a glimpse into Nebraska's geologic past. Here are excellent exposures of the Ogallala Group, which consists of continental sedimentary rocks deposited during the Miocene epoch of the Tertiary period of geologic time. This group of rocks extends throughout much of Nebraska (see geologic bedrock map on outside back cover) but is overlain in most places by younger stream and wind deposits of Pliocene(?) and Pleistocene age. Easily accessible, the Ogallala

outcrops contain locally abundant fossils of seeds, casts of pedotubules, and occasional fossils of vertebrate animals such as rhinoceroses, horses, elephants, and camels. Pedotubules are tubular openings in soil. They may have been made by plant roots or by worms, insects, or other animals.

The vicinity of Lake McConaughy is significant to the state both geologically and economically because it is underlain by water-saturated gravel and sandstone deposits that yield water for irrigation, livestock use, and human consumption.

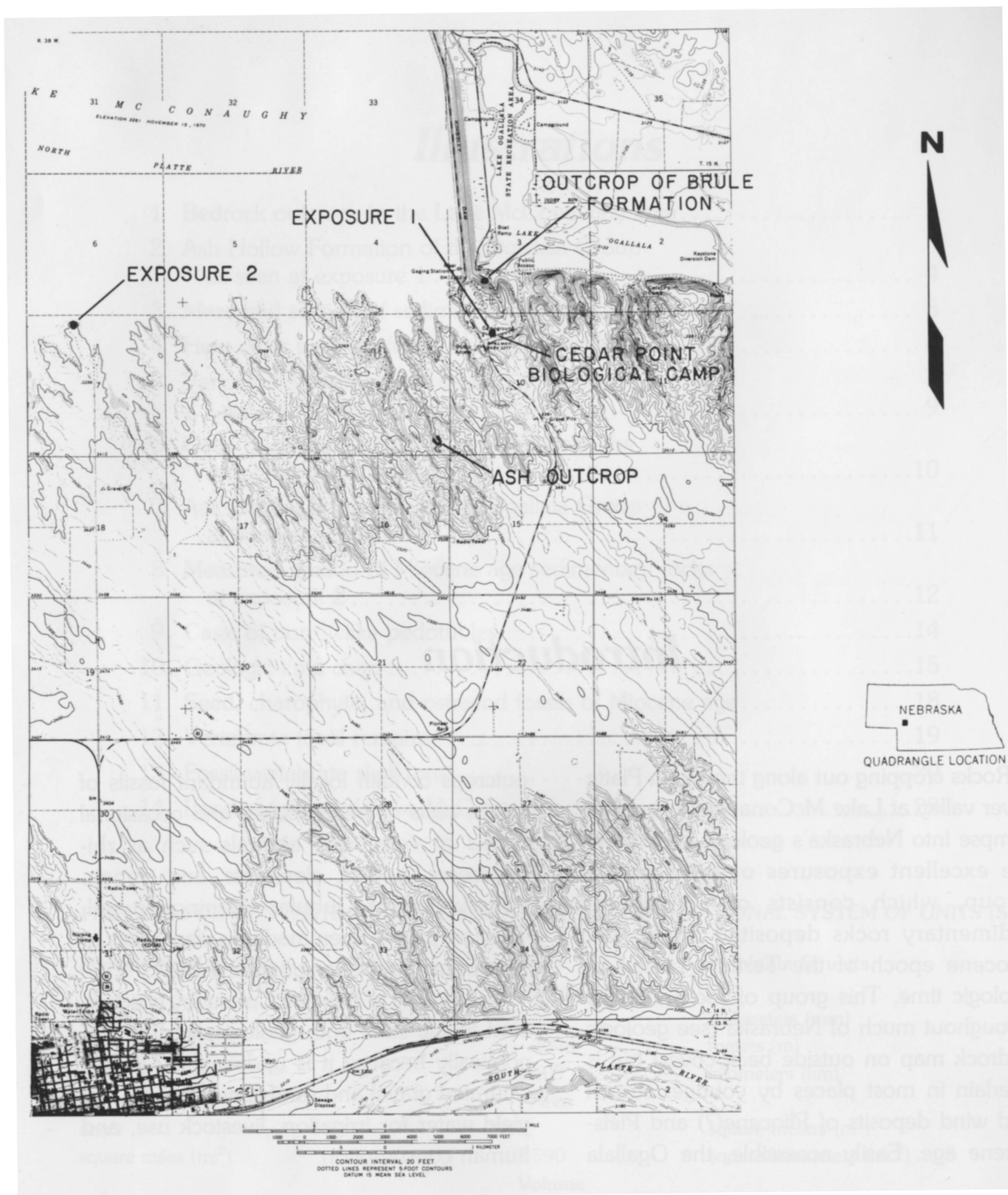


Fig. 1. Bedrock outcrops in the Lake McConaughy area are indicated on this topographic map of the Ogallala Quadrangle. Base map: U.S. Geological Survey, 7.5-minute series (topographic).

Exposure locations and elevations

Exposure 1, located in Keith County, is in the NE1/4 NW1/4, sec. 10, T. 14 N., R. 38 W., and is close to Lake McConaughy's overflow spillway. The elevation at the spillway is 3,277 feet above mean sea level.

Exposure 2, also in Keith County, is in the N1/2 NE1/4 NW1/4, sec. 7, T. 14 N., R. 38 W. Its base is at lake level, the elevation of which on November 15, 1970, was 3,261 feet above mean sea level.

How to reach the exposures

Use a Nebraska highway map to proceed from your starting point to Ogallala, Nebraska. From the junction of U.S. Highways 26 and 30 in downtown Ogallala, proceed north for 2.5 miles along combined routes U.S. Highway 26 and State Highway 61 to the point where the two routes diverge. (See fig. 1.) Veer right (east) on State Highway 61 and follow it due east, then northeast, and finally northwest for a total distance of 5.8 miles. Exposure 1 is behind the grounds of the Cedar Point Biological Camp on the right (northeast) side of the highway.

To reach exposure 2 from exposure 1, return to the junction of Highways 61 and 26. Proceed north toward Ogallala Beach along the graveled county road for 2.5 miles, then veer left and continue 0.3 mile along the trail leading to the special use area of the Nebraska Game and Parks Commission. Because the outcrop is on the north end of the point

extending into Lake McConaughy, the last 200 yards must be traversed on foot.

Exposed rocks

Several interesting chapters in the geologic history of Nebraska can be deciphered from the rocks exposed near Lake McConaughy. Occurring there is a rather thick sequence of continental sedimentary rocks deposited during the Miocene epoch of the Tertiary period. The age of these continental sediments, called by geologists the Ash Hollow Formation of the Ogallala Group, is from about 6 to 11 million years. In contrast, the sand hills on the north side of the North Platte River are definitely less than a half million years old and may be only a few thousand years old.

By interpreting fossils, geologists are able to determine both the geologic age of deposits and the environments in which the deposits were formed. The continental sandstones and siltstones contain fossil seeds, pedotubule fillings, and occasional fossils of vertebrate animals. The most abundant fossils in these rocks are seeds similar to those of many plants now growing naturally in the North Platte River valley. The presence of fossil seeds in sedimentary deposits that differ greatly in texture both laterally and vertically indicates that most of these deposits may have been laid down in the channels and on the floodplains of ancient streams.

Figure 2 illustrates the overall appearance of exposure 1 and figure 3 illustrates diagrammatically the sequence of rock layers cropping out in the exposure. Following figure 2 is a detailed description of the rock layers numbered in sequence from the bottom to the top of the exposure.



Fig. 2. Ash Hollow Formation of the Ogallala Group, as seen at exposure 1. Subsequent slumping may have altered the appearance of the exposure. Direction of view is toward the northeast.

Exposure 1
Stratigraphic section at picnic area,
Lake McConaughy

Quaternary System

Pleistocene Loess

- Unit 21. Loess, tan silt and very fine sand, undifferentiated; thickness not measured. Part of exposure may have been disturbed during dam construction.

Tertiary System

Pliocene (?) Series

- Unit 20. Gravel; thickness not measured.

Miocene Series, Ogallala Group

Ash Hollow Formation

- Unit 19. Gray, silty, sandstone; thickness as much as 12.0 feet. Abundant vertical pedotubule fillings resembling yucca roots.
- Unit 18. Hard, white, sandy caliche; thickness about 1.0 foot. Abundant swallow nests on the lower bedding surface.
- Unit 17. Very fine, light pink-gray, friable sandstone with four hard, ledge-forming layers toward west end of exposure; thickness about 10.5 feet. Abundant small pedotubule fillings resembling rootlets.
- Unit 16. Somewhat cross-bedded, very coarse gravel; thickness about 1.8 feet.

- Unit 15. Cross-bedded, light pink-gray, very coarse grained sand and gravel; coarsest gravel at top of unit; thickness about 1.5 feet.

- Unit 14. Light pink, very fine grained, sandy siltstone; thickness about 1.5 feet.

- Unit 13. Massive, light chocolate-brown, clayey siltstone; thickness about 4.0 feet.

- Unit 12. Layered, light chocolate-brown, silty, very fine grained sandstone; thickness about 0.9 foot.

- Unit 11. Layered, brown and white, very fine grained, sandy siltstone; thickness about 2.5 feet.

- Unit 10. Slabby, white to light gray caliche and stringers of light chocolate-brown silt; thickness about 1.0 foot.

- Unit 9. Brown and white banded, slightly sandy siltstone; thickness about 4.0 feet.

- Unit 8. Light chocolate-brown, sandy siltstone; thickness about 3.8 feet. Abundant small pedotubule fillings resembling rootlets and some fossil seeds.

- Unit 7. Light brown, very hard sandstone; thickness about 4.1 feet. Abundant small pedotubule fillings resembling rootlets.

- Unit 6. Light reddish brown, friable, slightly silty sandstone; thickness about 3.6 feet. Some pedotubule fillings resembling burrows.

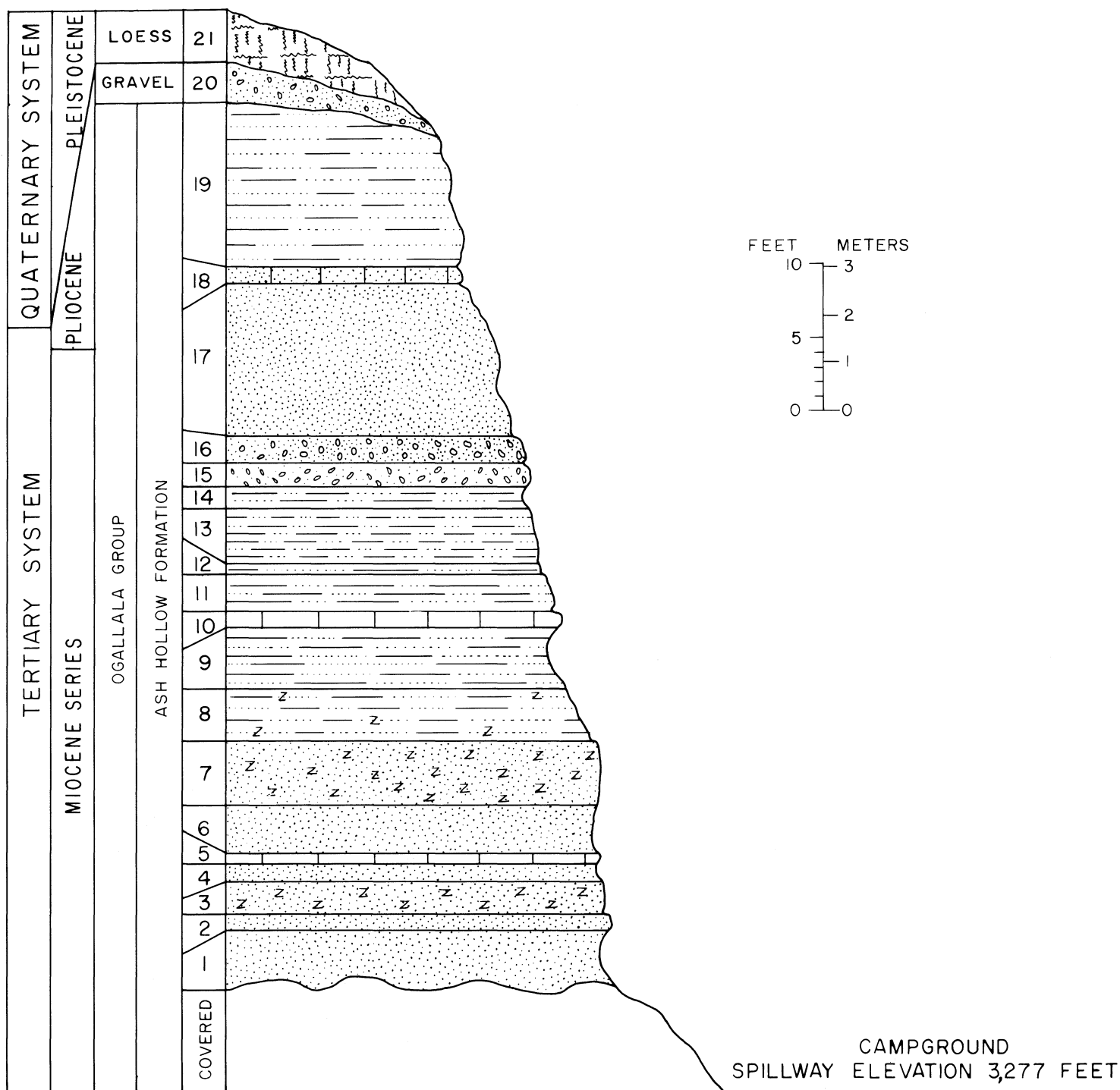


Fig. 3. Measured section of Miocene, Pliocene (?), and Pleistocene age sedimentary rocks at exposure 1.

- Unit 5. White, hard caliche; 0.1 to 0.3 foot thick.
 - Unit 4. Friable, light chocolate-brown sandstone; thickness about 1.8 feet.
 - Unit 3. Friable, light grayish green sandstone; thickness about 2.1 feet. Some small pedotubule fillings resembling root-lets.
 - Unit 2. Hard, indurated, white to light gray sandstone; thickness about 0.8 foot.
 - Unit 1. Friable, light gray sandstone; exposed thickness as much as 4.0 feet.
- Covered interval; thickness as much as 6 feet.

At exposure 1, the sequence of sandstones and siltstones includes three beds of caliche (units 5, 10, 18) and a cross-bedded gravel (unit 16). The caliches probably consist of secondary calcite deposited by groundwater during the development of now buried soils. The cross-bedded gravel probably was a bar deposit in the channel of an ancient gravel-transporting stream. Cross bedding results when sediment is shifted by currents in such a way as to be spilled over the slip face (downstream face) of an irregularity on the floor of the channel. (See fig. 4.) Since slip faces slope in a downstream direction and cross beds are parallel to slip faces, cross beds give the geologist reliable evidence of the flow direction of ancient streams. Sediment layers deposited by a stream on its floodplain generally are not cross-bedded but are bedded

parallel to the floodplain surface. They may be fine to coarse textured, depending on the velocity of the current at the time they were deposited. Often they contain fossil evidence of plant life because floodplains commonly support vegetation. At exposure 1 the Ash Hollow sediments represent three different depositional environments—soil formation, deposition in stream channels, and deposition on floodplains. (See fig. 5.) Eolian (wind-deposited) sediments of Pleistocene age represent a fourth depositional environment.

Of special interest at exposure 1 are the vertically elongate siliceous concretions resembling large plant roots, especially in unit 19. (See figs. 3 and 6.) White and up to 6 inches in diameter, these are as much as 15 feet long. Numerous tiny casts produced by plant, animal, or inorganic processes also are present.

Some of the siltstones at exposure 1 probably contain some shards of volcanic glass bubbles in ash expelled during volcanic eruptions in the Rocky Mountain area. A lens of volcanic ash has been reported in the Ogallala Group exposed within the Cedar Point Biological Camp, but the camp area is not accessible to the general public. However, an exposure of a similar ash deposit is accessible just above the valley floor in the SE $\frac{1}{4}$ SE $\frac{1}{4}$, sec. 9, T. 14 N., R. 38 W. It is on private property and can be reached only by walking. (See fig. 1.)

At exposure 2 (figs. 7 and 8), the sequence of rock layers, as described in detail on the page following figure 8, is not nearly so thick as at exposure 1 but is equally interesting.

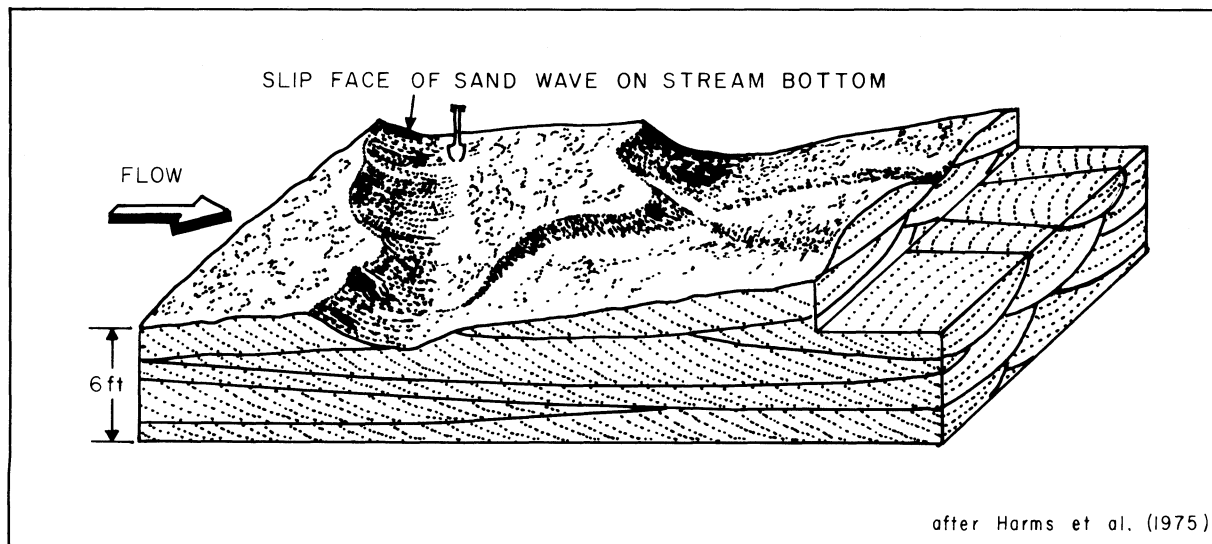
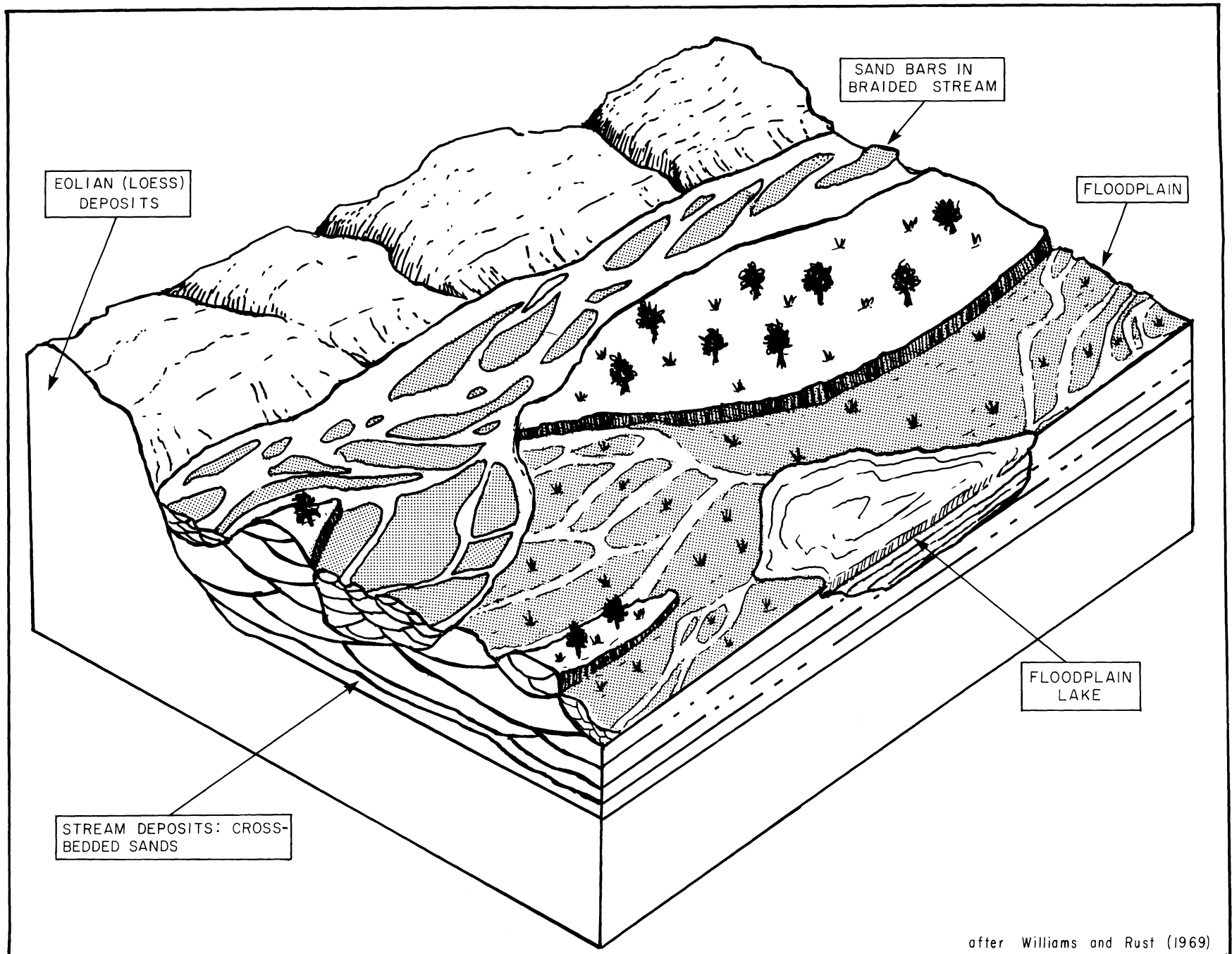


Fig. 4. Block diagram showing how cross bedding forms in stream deposits.



after Williams and Rust (1969)

Fig. 5. Block diagram showing the various environments of deposition that existed during Miocene, Pliocene (?), and Pleistocene time in the Lake McConaughy region. All these environments occur along the modern Platte River.



Fig. 6. Casts of elongate siliceous concretions as seen in the Ash Hollow Formation of the Ogallala Group.



Fig. 7. Ash Hollow Formation of the Ogallala Group as seen at exposure 2. Subsequent slumping may have altered the appearance of the exposure. Direction of view is toward the south.

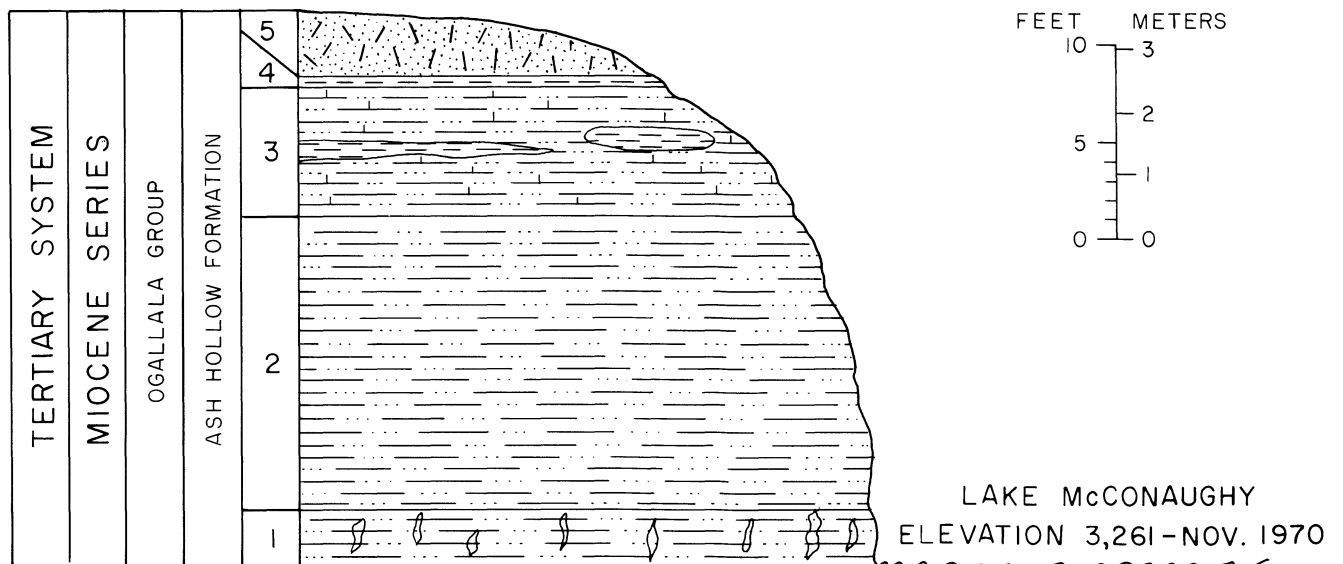


Fig. 8. Measured section of Miocene age sedimentary rocks at exposure 2.

Unit 1 (fig. 7) is a siltstone that contains numerous pedotubule fillings resembling roots and burrows (fig. 9). Such indicators of ancient life are referred to as trace fossils, which also include tracks or molds of organisms but generally no part of the organisms themselves. The trace fossils here may have been made by clams, crayfish, or large worms.

About 22 feet of siltstone overlies unit 1. The upper 7 feet of this siltstone contains a lens of green clay 1 foot thick and an irregular lens of brown claystone, also 1 foot thick. In 1975 a Chadron State College field party collected a fossil rhinoceros skull from the green clay lens. This clay probably represents sedimentation in a shallow pond or mudhole, but an origin for the brown claystone lens is yet to be suggested. Many vertebrate fossils collected elsewhere in Nebraska from beds of the same age are on display at the University of Nebraska State Museum in Lincoln.

Above the siltstone at exposure 2 is a 4-inch thick layer of red clay that may represent a paleosol, which is a fossil soil. A paleosol indicates that conditions were reasonably stable long enough for a soil to form. Since silt is a common floodplain deposit (fig. 8), the siltstone overlain by a paleosol may indicate that an ancient stream course had stabilized at this location and that frequent scouring of its floodplain no longer occurred. Mud cracks at the top of the red clay also may indicate that the red clay represents a paleosol.

Exposure 2 Stratigraphic section at Lake McConaughy

Tertiary System

Miocene Series, Ogallala Group

- Unit 5. Arkosic sand and gravel; some cross bedding; thickness about 3 feet; somewhat thicker toward the east. Soil on top.
- Unit 4. Red clay; possible paleosol horizon; thickness about 7 inches. Vertical fractures at top of unit are filled with downward extensions of unit 5.
- Unit 3. Light greenish gray, limy siltstone; thickness about 7 feet. Contains a brown claystone lentil about 1 foot thick and a green clay lens also about 1 foot thick.
- Unit 2. Brown siltstone; thickness as much as 15 feet. Covered by rubble in some places.
- Unit 1. Light to medium gray siltstone; exposed thickness 2 to 3 feet. Numerous pedotubules resembling burrows.



Fig. 9. Casts of burrowlike pedotubules, as seen in unit 1 at exposure 2.

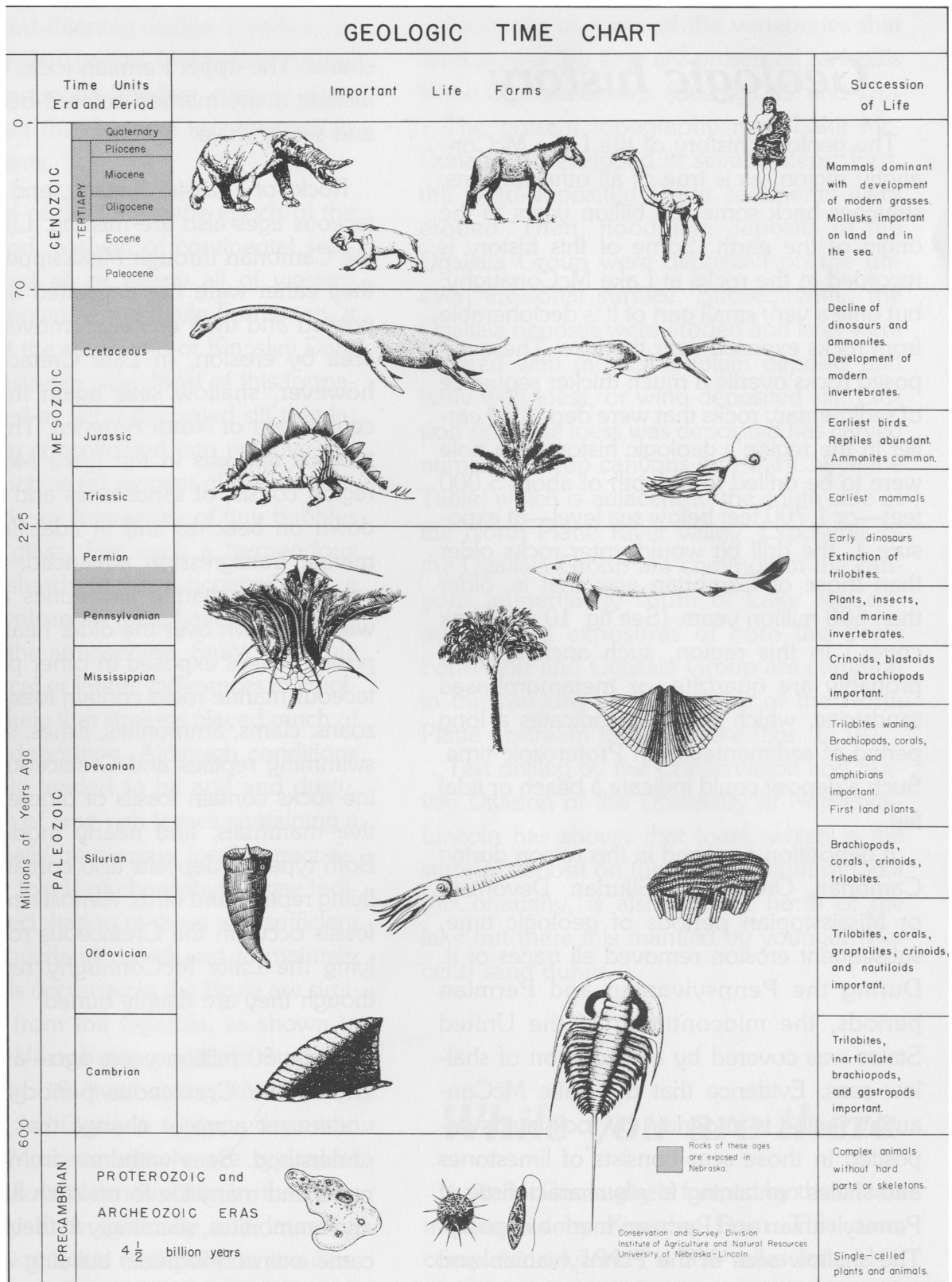


Fig. 10. Geologic time chart. The shaded parts of the time units indicate the age of rocks exposed in Nebraska.

Geologic history

The geologic history of the Lake McConaughy region, as is true of all other regions, stretches back some 4.5 billion years to the origin of the earth. Some of this history is recorded in the rocks at Lake McConaughy, but only a very small part of it is decipherable from rocks exposed near the lake. These exposed rocks overlie a much thicker sequence of sedimentary rocks that were deposited earlier in the region's geologic history. If a hole were to be drilled to a depth of about 5,000 feet—or 1,700 feet below sea level—at exposure 1, the drill bit would enter rocks older than those of Cambrian age; that is, older than 600 million years. (See fig. 10 and back cover.) In this region, such ancient rocks probably are quartzite, or metamorphosed sandstone, which probably indicates a long period of sedimentation in Proterozoic time. Such a deposit could indicate a beach or tidal flat.

If deposition occurred in this region during Cambrian, Ordovician, Silurian, Devonian, or Mississippian periods of geologic time, subsequent erosion removed all traces of it. During the Pennsylvanian and Permian periods, the midcontinent of the United States was covered by a succession of shallow seas. Evidence that the Lake McConaughy region is underlain by rock layers deposited in those seas consists of limestones and shales containing fossils characteristic of Pennsylvanian and Permian marine deposits. The shallow seas of the Pennsylvanian and Permian periods teemed with algae, other marine vegetation, protozoans, sponges, corals, bivalves, snails, brachiopods, echinoderms, trilobites, primitive fishes, and

sharks. The upper Permian rocks in this area include many maroon-colored beds of shale and sandy shale.

Rocks of Triassic, Jurassic, and Early Cretaceous ages also are missing. Like rocks in the Cambrian through Mississippian periods, they either were not deposited or were deposited and then entirely removed from the area by erosion. In Late Cretaceous time, however, shallow seas again invaded the central part of North America. The first Cretaceous deposits in the Lake McConaughy region consist of sandstones and shales laid down on beaches and in tidal flats. As the marine transgression advanced, a younger sequence of marine limestones and shales was laid down over the older near-shore deposits. Where exposed in other places, Cretaceous marine rocks contain fossils of protozoans, clams, ammonites, fishes, sharks, and swimming reptiles and Cretaceous nonmarine rocks contain fossils of dinosaurs, primitive mammals, and nearly modern plants. Both types of deposits also contain fossils of flying reptiles and birds. Almost certainly such fossils occur in the Cretaceous rocks underlying the Lake McConaughy region, even though they are deeply buried.

Some 60 million years ago—at about the end of the Cretaceous period—the earth underwent a major change that is not well understood. Seas withdrew from the continents and many life forms such as dinosaurs and ammonites, seemingly at their zenith, became extinct. Mountain building in the western part of the United States was another feature of this major change, and the rising mountains were sources of sediment that not only filled intermontane basins but also built

up an eastward-thinning wedge of sediments during the Tertiary period. Volcanic eruptions during the mountain-building episode were sources of ash that became incorporated in those sediments.

By the end of the Oligocene epoch of the Tertiary period, a sheet of continental sediments covered all or nearly all of western Nebraska. Known as the Brule Formation, it is exposed at the south end of Kingsley Dam on the downstream side. Most of this formation originated as wind-deposited silt that later was partly consolidated into massive siltstone. As much as 60 percent of the silt consists of shards, or fragments, of tiny bubbles of volcanic glass. For such a tremendous quantity of shards to have accumulated, a great many volcanoes must have been spewing ash into the atmosphere. Since the Brule has few vertical or lateral differences in lithology, it is unlikely that streams played much of a role in its deposition. Although conditions then probably tended to be arid and dusty, the existence of lime-rich lenses containing a few fossil snails, numerous fossil ostracods, and possibly fossils of charophyte algae indicates that precipitation at times was sufficient to produce overland runoff and to maintain ponds. Fossils occurring in the Brule are similar to those from the Ogallala, as shown in figure 11. Vertebrate animals such as oreodonts (fig. 12) lived during this time.

Rocks of the Ogallala Group, deposited during the Miocene epoch, are typical of stream and floodplain deposits in that they differ greatly both vertically and laterally. Typical environments of deposition are illustrated in figure 5. The presence of fossil seeds of grasses and borage herbs (fig. 11) indicate that the floodplains and probably the interstream uplands supported meadows.

Skeletons of some of the vertebrates that lived during this time are preserved as fossils in the Ogallala Group. (See figs. 12 and 13.)

The present topography near Lake McConaughy developed in several steps. First, the wind-deposited Brule sediments were eroded. Then, floodplain deposits of the Ogallala Group were deposited on the uneven erosional surface. Subsequently, the Ogallala deposits were eroded and later were covered with more floodplain deposits and lastly with loess, or wind-deposited silt. Erosion since the loess was deposited has carved numerous deep canyons into the Cheyenne Table, which is adjacent to the south side of the North Platte River valley. Exposures of the Ogallala Group are common in the canyons immediately south of Lake McConaughy, and exposures of both the Brule Formation and Ogallala Group are common in the canyons on both sides of the North Platte upstream from the lake (figs. 1, 14).

Test drilling by the Conservation and Survey Division of the University of Nebraska—Lincoln has shown that loess, which is the surficial deposit on the upland south of Lake McConaughy, is also present north of the lake but there it is mantled by younger (Recent) sand dunes.

While you are there

Lake McConaughy is formed by the waters impounded by Kingsley Dam. This dam, completed in 1941, is 3½ miles long, 162 feet high, and 1,100 feet wide at its base. It contains about 25 million cubic yards of material, the core being made up of Pleistocene loess and the exterior being made up

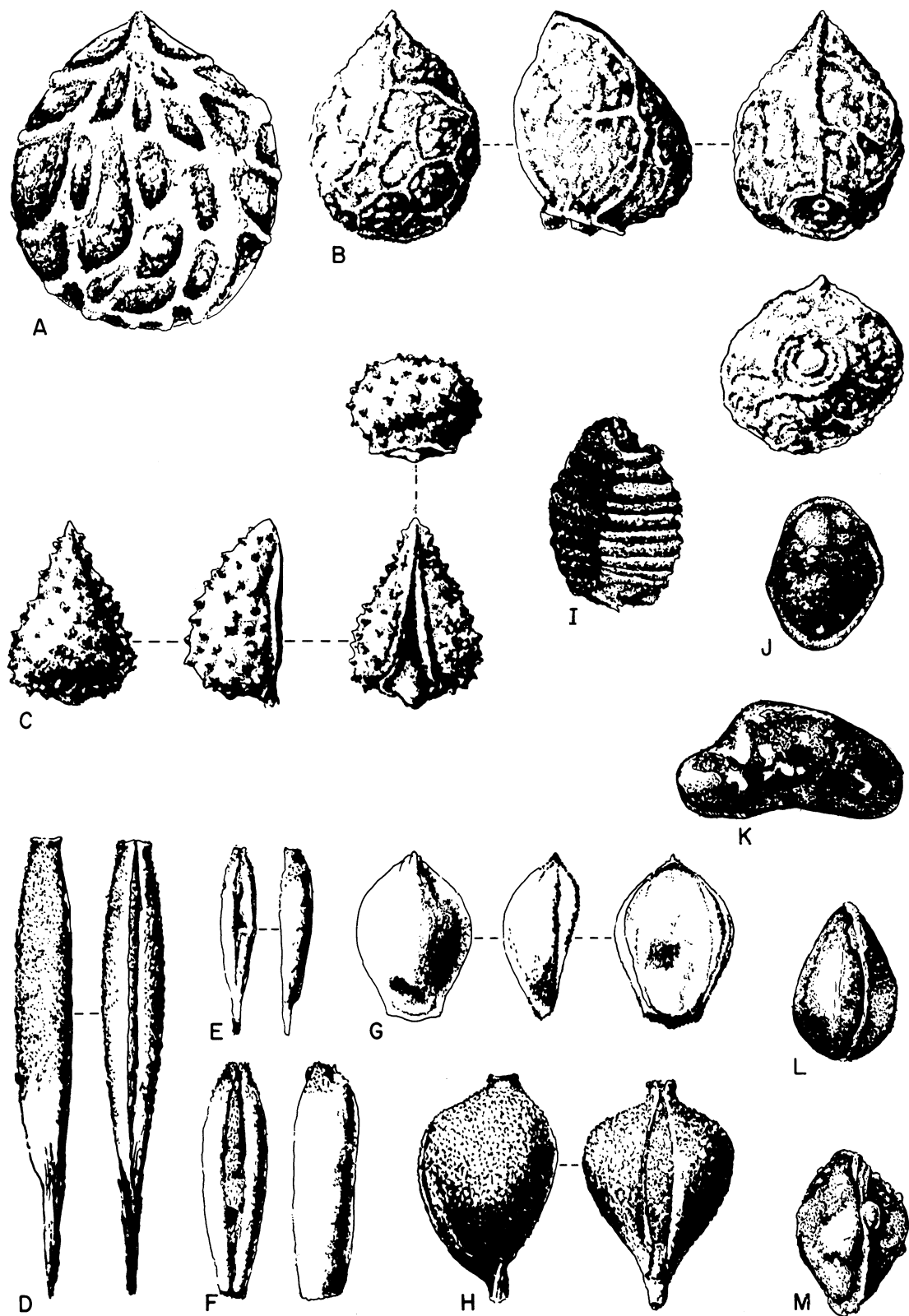


Fig. 11. Seed, charophyte, and ostracod fossils of Miocene age. (A-H: seeds and grains) A. Hackberry, *Celtis*, X 15. B. *Biorbia*, X 15. C. *Cryptantha*, X 15. D. *Berriochloa* sp., X 12. E. *Berriochloa* sp., X 12. F. *Berriochloa* sp., X 12. G. *Panicum*, X 18. H. *Berriochloa*, X 12. I. Charophyte, *Chara*, X 100. J. Ostracod, X 32. K. Ostracod, X 32. L. Ostracod, X 32. M. Ostracod, X 32. (Figs. 11B-11H after Schultz and Stout, 1941, p. 17)

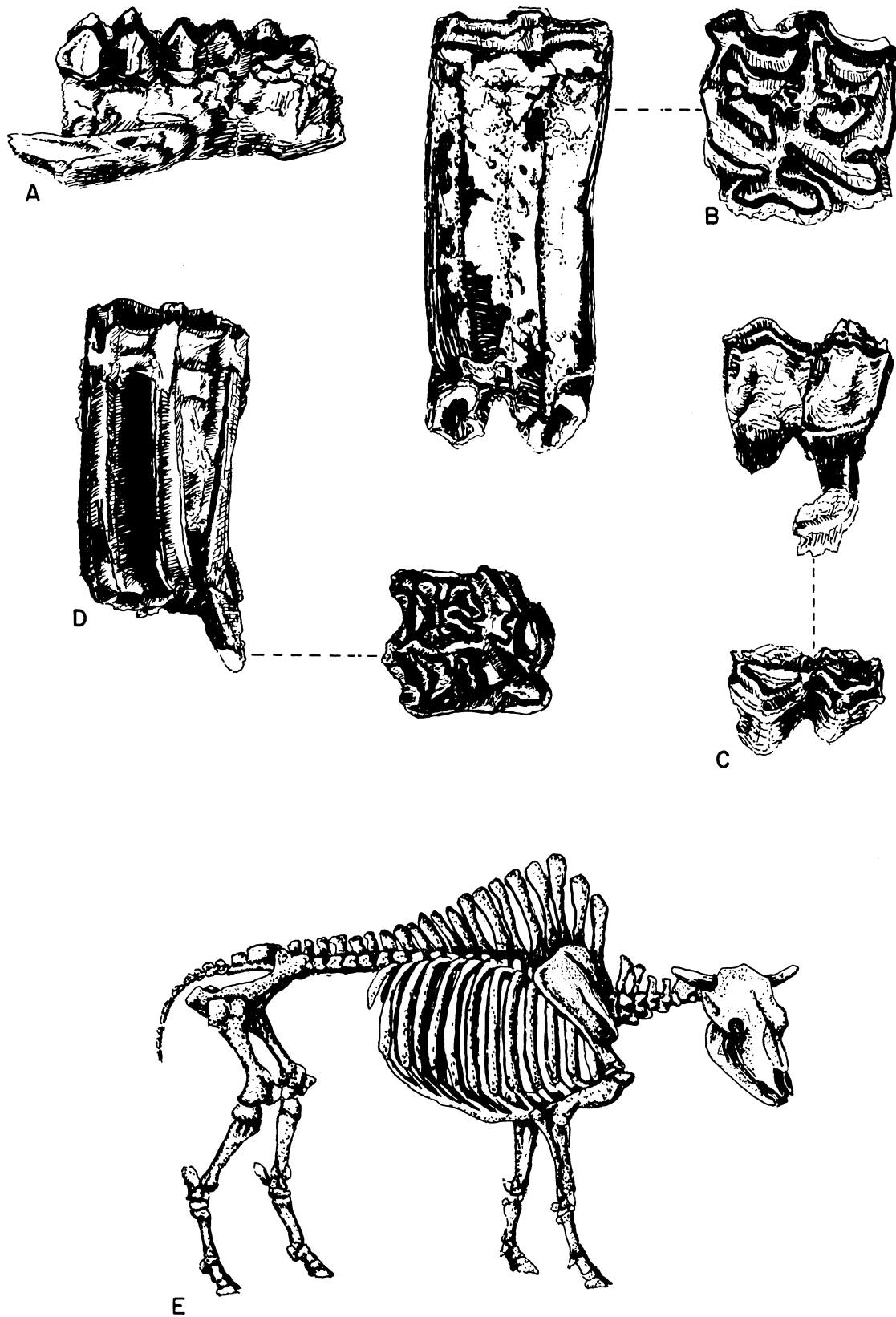


Fig. 12. Vertebrate fossil remains. A. Oreodont tooth, X 1. B. Horse tooth, X 1. C. Camel tooth, X 1. D. Horse tooth, X 1. E. Bison skeleton, X 1/15.

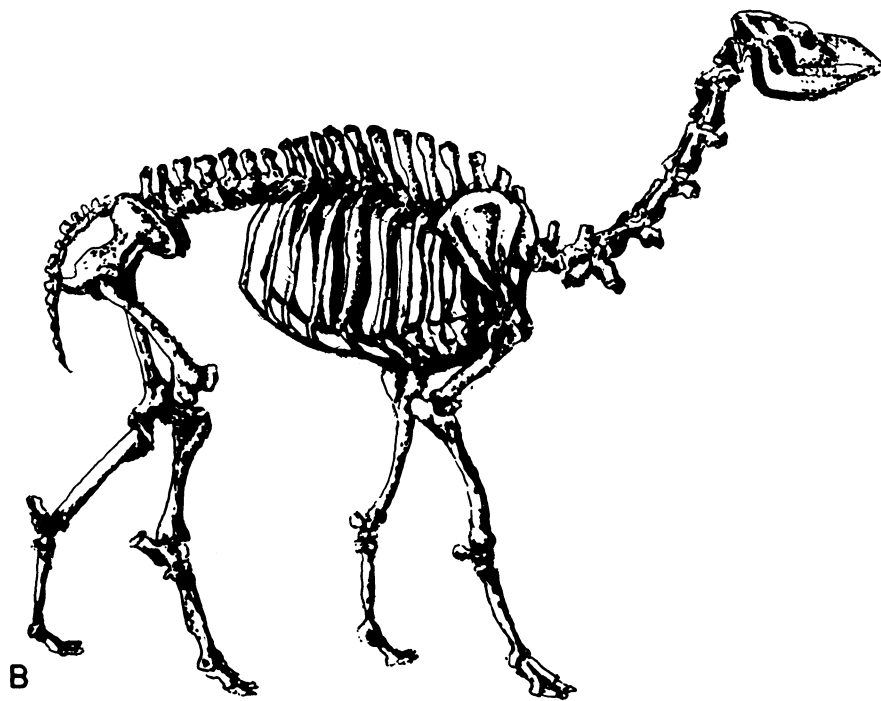
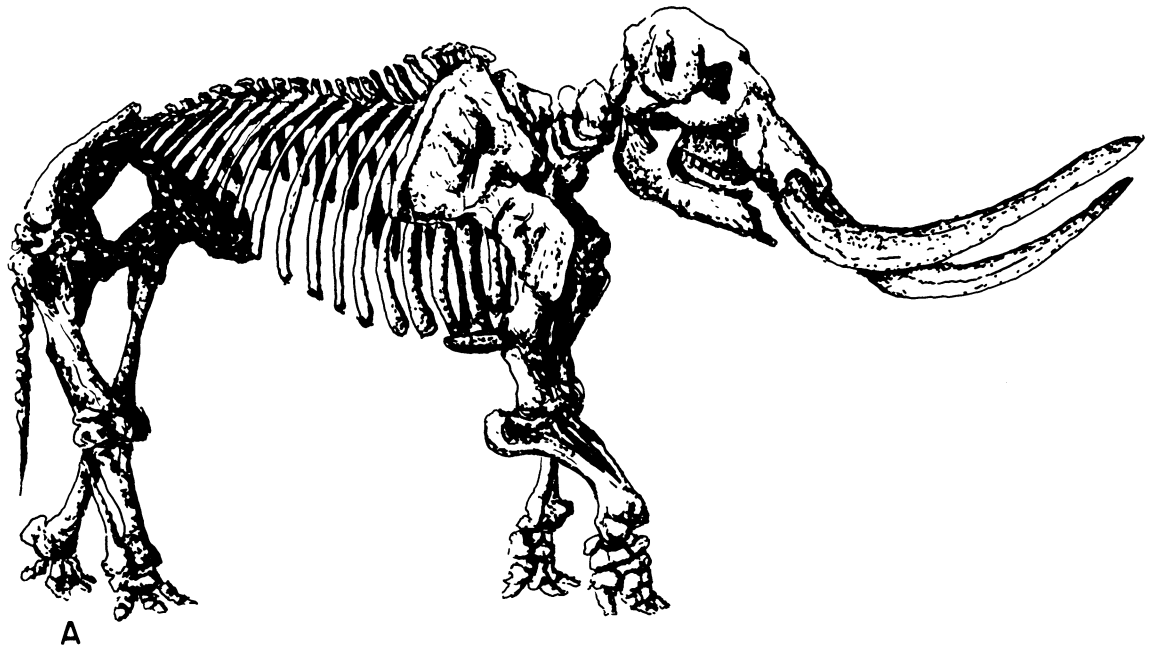


Fig. 13. Fossil vertebrate skeletons. A. Mastodon, X 1/30. B. Camel, X 1/20.

of Pliocene(?) and Recent sand and gravel. The loess came from the upland south of the dam and the sand and gravel from a borrow pit below the dam. Filled with water, that borrow pit now forms Lake Ogallala. Some of the camping and picnic facilities available near Lake Ogallala were donated by the Prairie Rockhounds, a rock collectors' club headquartered in Ogallala.

Erosion subsequent to regional uplift together with the North Platte River's capacity to transport the products of that erosion account for the topography of this area. The river drains and transports erosional wastes from an area of 29,300 square miles upstream from Kingsley Dam. Much of the river's flow is meltwater from snow accumulations on the mountainous headwater area.

Controls at the dam consist of a control tower for operation of the outlet gates and the emergency flood-control spillway, shaped like a morning glory and commonly referred to as such (cf. front cover). The spillway, which is 101 feet in diameter and has 12 gates, can discharge water at a maximum rate of 54,000 cubic feet per second, or a little more than 100,000 acre-feet per day.

When full, Lake McConaughy holds 1,948,000 acre-feet of water between the sill of the outlet gates and the top of the spillway gates. The lake is 22 miles long, is as much as 4 miles wide, and has a maximum depth of 142 feet.

Well known for excellent fishing, Lake McConaughy contains catfish, bullheads, perch, crappie, white bass, and walleyes—all in sufficient numbers to be attractive to most anyone who likes to fish.

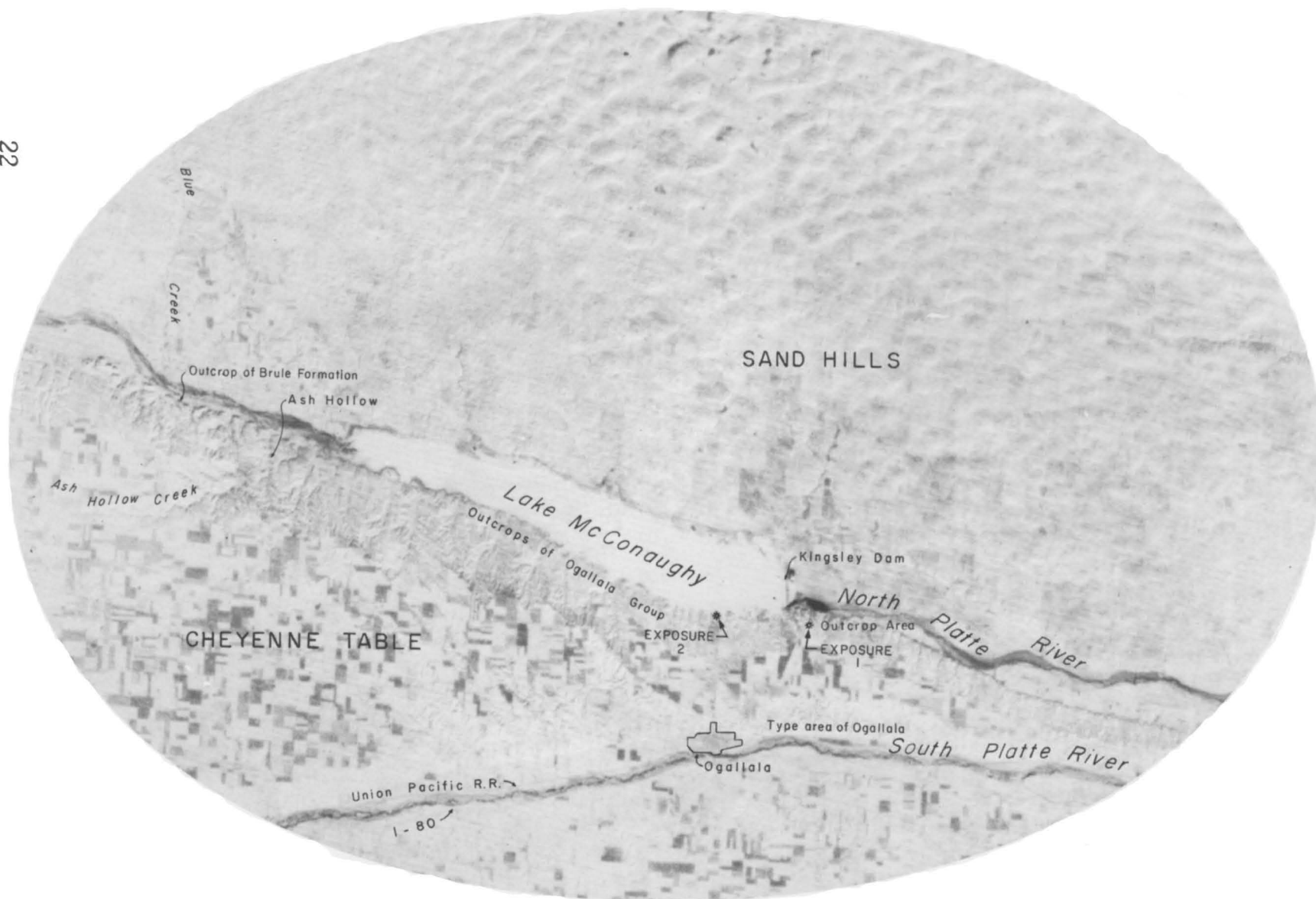
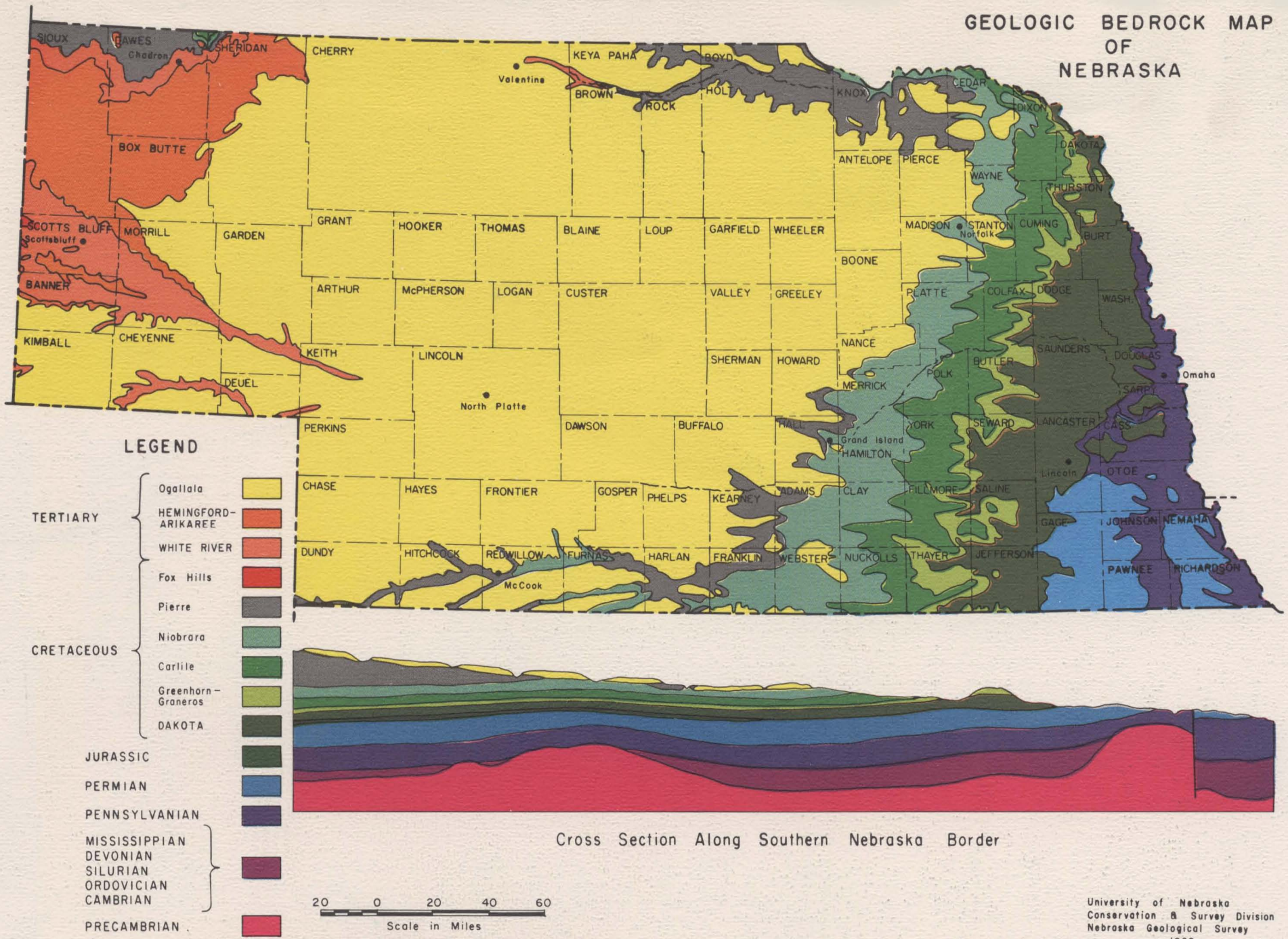


Fig. 14. Landsat image of the Lake McConaughy area showing key features.

GEOLOGIC BEDROCK MAP OF NEBRASKA



NOTE: Unconsolidated sediments of Pleistocene age cover the bedrock throughout much of the State and are not shown.